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STORAGE AND GERMINATION OF CALIFORNIA CORK-OAK ACORNS

By

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INTRODUCTION

Cork-oak acorns are known to be extremely perishable, but exact information on their storage is surprisingly meager. Spanish and French literature on the subject is disappointingly general. Recently some fundamental work has been done in Russia on cork oak, but great climatic and ecologic differences between southern Russia and California warranted an independent study of handling cork-oak acorns under local conditions. The numerous cork-oak trees now growing in California produce an ample quantity of acorns both for experimental work and, if economically handled, for moderate-scale field planting. The ready availability of fresh acorns here in California is an advantage in experimental storage and germination. On the other hand, gathering acorns from widely scattered trees whose pedigree is not known to the experimenter is a serious drawback in research.

In Europe cork is harvested from three species of oak: Quercus suber L., Q. occidentalis Gay (which is considered by some as a variety of Q. suber), and Q. pseudosuber Santi (which is a hybrid between Q. suber and Q. cerris). Q. pseudosuber is of a limited distribution and it produces cork of an inferior quality. It is doubtful if this oak has been introduced to California. Q. suber grows in Europe under environmental conditions very different from those under which Q. occidentalis grows. The two trees differ a great deal in their height, their latitudinal and altitudinal distribution, and their soil and climatic requirements. Besides these two major forms there are many ecologic races of cork oak.

* MAINTAINED AT BERKELEY, CALIFORNIA, IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA.

Cork oak has been grown in California since the fifties, and at present there are several groves and numerous individual trees scattered throughout the warmer parts of the State. Cork-oak trees are found in southern California, in the Sacramento and San Joaquin valleys, and in some localities of the central coastal regions, such as in the vicinity of San Francisco Bay, Napa, and Sonoma. The most northern localities that cork oak was planted on the coast appear to be near Fortuna and in the interior in the Sacramento valley near Chico. In the Sierra Nevada foothills cork-oak trees are found as high as 2,600 feet above sea level.

In the introduction of cork oak to California, apparently no attempts were made to plant different varieties of cork oaks in appropriate places. Judging from the size of acorns and the time of fruiting, it appears that many different varieties of cork oak were introduced to California. To consider the taxonomic and ecologic variations of California cork oaks is beyond the scope of this paper, but it is necessary to point out that the acorns used in the experiments did not necessarily belong to the same variety of cork oak. The material used was by no means taxonomically homogeneous.

In a preliminary study the heterogeneity of the acorns did not seem too important, since the acorns received from many localities exhibited similar tendencies in germination and storage. In further studies it appears desirable to use more homogeneous material.

CHARACTERISTICS OF CALIFORNIA CORK-OAK ACORNS

Cork oak belongs to the white oak group and its acorns possess most of the distinguishing characteristics of the group. White-oak acorns, including those of cork oak, usually germinate in the autumn, and black-oak acorns usually do not germinate until spring. In other words, the former do not exhibit the phenomenon of dormancy, but the latter do and are accordingly characterized by delayed germination (Korstian, 6).

Cork-oak acorns germinate promptly after they fall from the trees, provided, of course, that the ground is moist. Although they germinate slowly at temperatures as low as 32°F., the optimum temperature for their germination is between 59° and 77° F. (Pravdin, 8).

In some respects, however, germination of cork-oak acorns differs considerably from that of other oaks, and this difference has an important bearing on their practical handling. In all oaks germination begins with longitudinal splitting of the shell (fruit coat) at the apex of the acorn. The radicle then emerges and the petioles of the cotyledons elongate so that they carry the plumule outside of the shell (Korstian, 6). In most oaks the hypocotyl is very short. In *Q. robur* it is only 2 to 3 mm. long. In *Q. pedunculata* also it is almost wanting; 2 months after germination, when the shoot reaches 11 cm. and the root is 33 cm. long, the hypocotyl is only 0.3 cm. long (Kirchner et al., 5). The behavior of cork oak is different. Germination is prompter than in many

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other white oaks. The root emerges very soon after the acorns are planted — in 2 or 3 days. The shoot appears in 7 to 10 days after planting. From table 1 it is seen that the appearance and growth of the shoot in relation to the root vary a great deal.

Table 1.— Shoot and root length of a few cork-oak seedlings

Length in cm.			:
Shoot	:	Root	:
			Root-shoot ratio
0.25		15.5	62 : 1
0.75		9.0	12 : 1
1.0		5.0	5 : 1
5.5		23.5	4 : 1

The most interesting thing about the germination of cork oak is that the first 10 - 15 cm. of the "root" is not a root proper, but the hypocotyl; it has the anatomical structure of a stem and not of a root (Pravdin, 8). At 10 to 15 cm. below the cotyledons the real root appears. The first stage of germination consists of intercalary growth. This intercalary growth takes place in the zone in which the cotyledons are attached to the stem. Two rows of buds are formed on the whole length of the hypocotyl. When the plumule or the young shoot is removed these hypocotyl buds develop into shoots, as shown in figure 1. Root hairs are formed frequently on the hypocotyl. It is rather a widespread opinion that decapitated cork-oak seedlings give root sprouts. In view of the facts noted above, it is seen that of the subterranean parts of the seedlings only the hypocotyl forms epicormic ^{1/} buds that may give rise to shoots. The root proper does not produce epicormic buds.

Cork-oak acorns used in these experiments were collected chiefly in two California localities: from a 38-year-old plantation near Chico and from 20-year-old roadside trees at the University of California, Davis, in November and December 1942. In room-storage tests, acorns collected in the Napa valley were used. Smaller lots were received from several other places in California, but the acorns of these lots were used only for determining variations in size and not for storage or germination tests.

The acorns collected in California in the autumn of 1942 varied greatly in size and accordingly in number per pound. The weight of 100 acorns in grams and the number of acorns in a pound are given in table 2 for several representative samples.

^{1/} Since the writer is in doubt whether the buds formed on the hypocotyl are dormant buds or adventitious ones, the more general term "epicormic" is used.

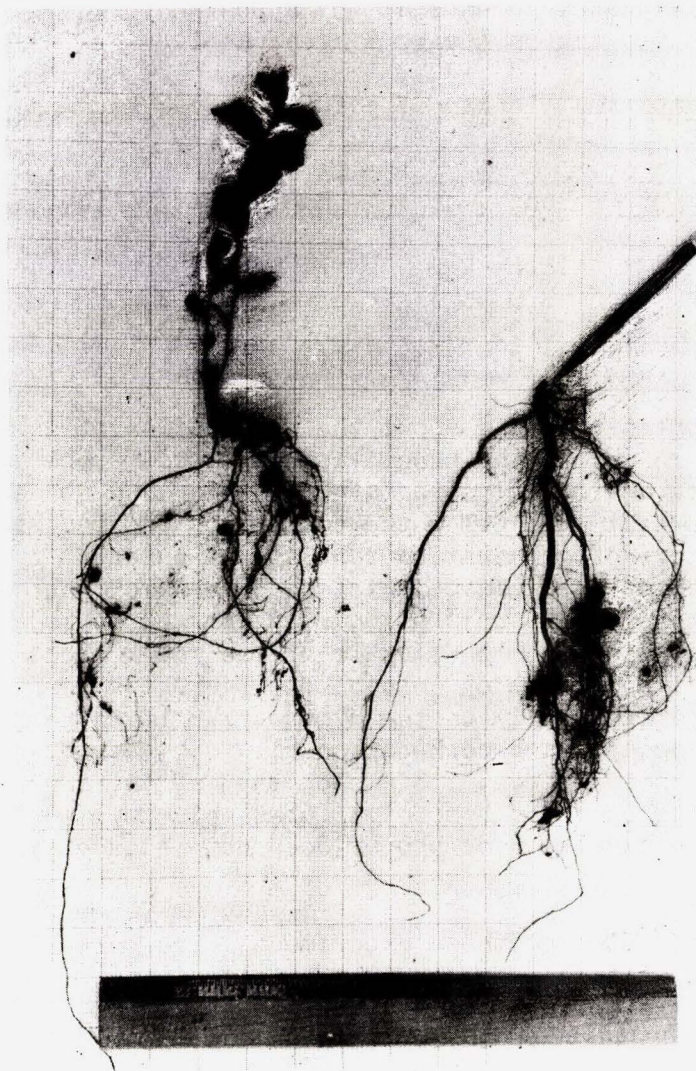


Figure 1.- Development of shoots from hypocotyl buds of decapitated cork-oak seedlings.

Table 2.-- Weight of 100 cork-oak acorns in grams and number of acorns in a pound of several lots collected in California in 1942.

Origin	: Weight of : 100 acorns grams	: Number in: : a pound	: Size of acorns
Rich Ranch, Kern County	805	56	Extra large
State Hospital, Napa County	675	67	Large
University of California campus,)	512	89	Average
Davis, Yolo County)	448	101	Average
Bidwell Park, Chico, Butte County	375	121	Average
" " " " "	315	144	Average
Street tree, Sonora	165	275	Extra small

Moisture content of cork-oak acorns and its relation to germination

The moisture content of one lot of fresh acorns was determined at the San Dimas Experimental Forest ^{2/}. Some of the acorns were collected from the tree, but the majority were picked up from the lawn within 5 days after they had fallen from the tree. The moisture of the acorns, determined by the xylene distillation method the day after collection, was 75 percent of the dry weight of the acorns.

At Berkeley the writer determined the moisture content of four lots of cork-oak acorns by drying 100 acorns of each lot at 221° F. for 24 hours. The moisture content was calculated on the basis of the oven dry weight of the acorns. The results are given in table 3.

Table 3.-- Moisture content of four lots of California cork oak acorns

Origin	:	:	Date of	:	:	:	Moisture
and	:	:	arrival	:	:	Date of	content,
lot	:	Date of	at	:	Temperature:	determining	based on
number	:	collection:	laboratory:	during	:	moisture	oven-dry
	:	(all 1942):	(all 1942):	storage	:	content	weight
							Percent
Chico #1		Nov. 17	Nov. 25	32° F		Dec. 22, 1942	57
Chico #2		Nov. 17	Nov. 25	32° F		Dec. 23, 1942	73
Davis #1		Dec. 13	Dec. 15	40° F		Jan. 4, 1943	67
Davis #2		Nov. 16	Nov. 27	40° F		Nov. 28, 1942	77

^{2/} Jerome S. Horton of the San Dimas staff made this determination.

The moisture content of Chico lot #1 seems to be abnormally low and of the other lots about equal. The acorns of Chico lot #1 and Davis lot #1 apparently lost some moisture in transit. Judging by Horton's data and by the figures obtained by the writer with Chico lot #1 and Davis lot #2, it may be concluded that moisture content of the ripe acorns, when they begin to fall from trees, is between 75 and 80 percent.

In order to determine the moisture content at which cork-oak acorns lose their viability, further tests were made with the above-mentioned lots of acorns. At the time of determining the initial moisture content, a quantity of acorns was brought to the laboratory (where the temperature was about 77° F.) and spread on a bench. At predetermined intervals 100 acorns were withdrawn from each lot; 50 were used for determining moisture content and 50 for determining germination capacity. Germination tests were made in the greenhouse in which the temperature fluctuated between 60° and 80° F. The results of these tests are shown in table 4 and in figure 2.

Table 4.- Loss of viability of California cork-oak acorns with loss of moisture in storage.

Origin	:	:	Days stored in laboratory												
and	:	Moisture	:	at 80° F.											
lot	:	and	:												
number	:	germination	:	0	2	3	4	5	6	7	8	9	10	12	
				<u>Percent</u>											
Chico #1	Moisture		58	49		40		32		28			24	22	
	Germination		76	60		20		5		0			0	0	
Chico #2	Moisture		73		60			46		35				30	
	Germination		80		64			38		4				0	
Davis #1	Moisture		67	56			45		38					33	
	Germination		92	58			34		10					0	
Davis #2	Moisture		77	68				54					38	35	
	Germination		90	64				29					5	0	

The following conclusions can be drawn from these experiments:

1. The moisture content of freshly collected acorns is apparently between 70 and 80 percent.
2. A moderate (perhaps 10 percent) loss of moisture between harvesting and planting acorns is not detrimental to the viability of the acorns.
3. In a warm room loose cork-oak acorns lose moisture very rapidly and after only 5 or 6 days most of the acorns perish.
4. When the moisture content of the acorns reaches 30 to 35 percent, they lose their viability.

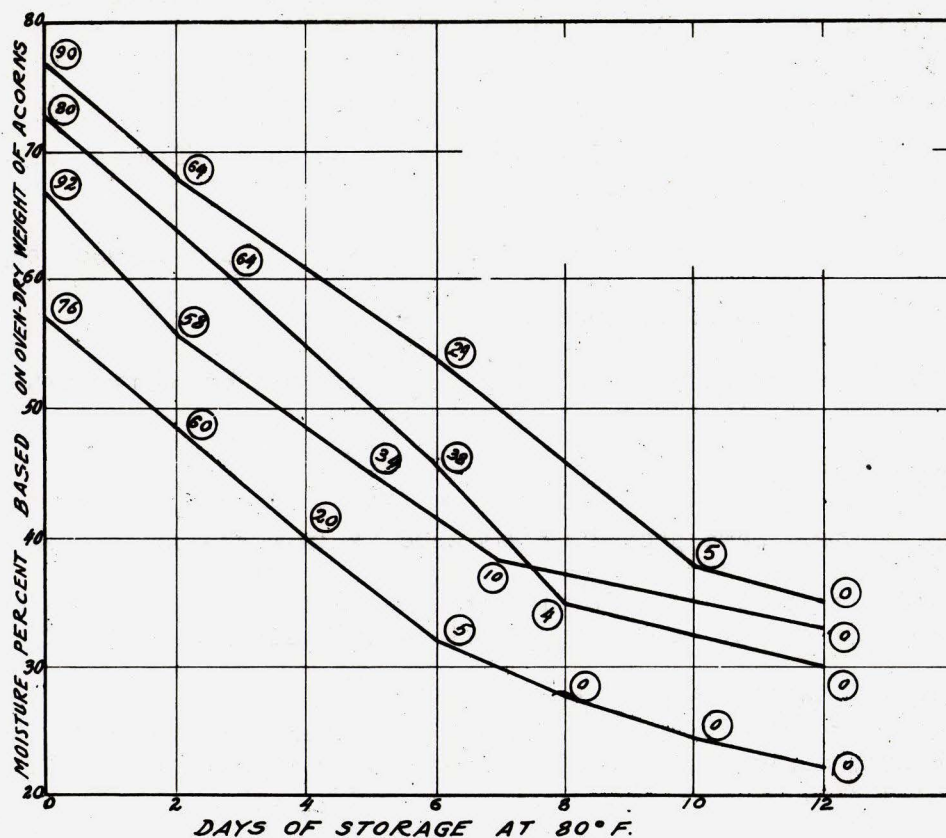


Figure 2.- Loss of moisture and decrease in germination with storage of cork-oak acorns. (Figures in circles denote germination percentage.)

In order to preserve a high degree of viability in cork-oak acorns, their moisture content should be kept well above 35 percent and as close to the original moisture content as possible. No attempt should be made to germinate cork-oak acorns when their moisture content is below 30 to 35 percent.

EXPERIMENTS WITH STORAGE OF CORK-OAK ACORNS

As cork-oak acorns are extremely perishable, some experiments were started late in 1942 to determine the best conditions for storage. The following storage conditions were tested:

Warm-room storage (70°-80° F.)

Loose, in laboratory. See preceding discussion of moisture content of cork-oak acorns.

Paper bags. For this test 100 acorns were placed in each bag.

Mixed with sand in an open wooden box.

In airtight jars, in laboratory. See discussion of preparation of cork-oak acorns for shipment.

Cold storage (32° F.)

Paper bags. Same procedure was used as in warm-room storage.

Mixed with sand and kept in airtight 5-gallon can. The acorns were mixed half and half by volume with air-dry sand.

Bulk, in an air-tight 5-gallon can.

This experiment was started 4 weeks later than the other experiments; during that time the acorns were stored in a burlap sack at 40° F.

In moist peat, in a 10-gallon can.

For this method of storage, known as stratification, an ash can was provided with an opening at the bottom, and a central aeration well was made of coarse screen, in order to assure free circulation of air. The can was loosely covered with a lid.

In 100-pound burlap sacks.

This was an incidental test of a lot of 10 sacks brought from Chico early in January and stored in a commercial cold-storage house for 10 weeks prior to distribution.

In the warm-room storage test, acorns collected in the Napa valley were used. In the cold-storage tests acorns collected at Davis were used. Using cork-oak acorns from two different localities in one experiment was perhaps not desirable, but since acorns received from many localities in California show very similar behavior in storage and germination, the results are considered reliable enough for general application.

The procedure for testing the viability of acorns stored under different conditions was as follows: An initial test of 400 acorns was made and afterwards 100-acorn lots were withdrawn from storage at prescribed intervals and germinated in the greenhouse in wooden flats filled with a mixture of sand and peat. Germination counts were made and the behavior of the germinating acorns was observed. The acorns were considered to have germinated when a normal and healthy root emerged from the shell to about one-half inch. The shoot usually appeared from 1 to 2 weeks after the emergence of the root. Under certain circumstances the rooted acorns never developed a shoot. This phenomenon will be discussed later. The results of the storage tests are presented in table 5.

In a warm storage room viability of cork-oak acorns kept in paper bags decreased rapidly and after 2 weeks it reached a very low level. The acorns kept in an open container filled with dry sand retained their viability for a longer time; cork-oak acorns can be kept under these conditions for perhaps 10 days, but not longer. Unfortunately room storage in airtight containers was omitted from this series of tests. Later experiments of this kind (see Preparation of cork-oak acorns for shipment, p. 14) showed that in airtight quart jars the acorns can be kept at room temperature of about 77° F. for 2 weeks.

Keeping the acorns in small individual paper bags in cold storage was also found to be unsatisfactory. Apparently the acorns lose moisture too rapidly under these conditions. On the other hand, if stored in 100-pound burlap sacks they can be kept in cold storage for as long as 10 weeks without appreciable loss of viability. Keeping oak acorns in a moist medium with an abundance of air (i.e., stratification) has been advocated by Johannsen(4). In the present study, stratification of cork oak acorns as a means of storage was found unsuitable. Germination took place even at 32° F., although it progressed but slowly. After 4 months of stratification the tips of emerged roots turned brown and died. At first this did not affect the development of seedlings. New roots were formed from the hypocotyl and since the shoot bud was not killed the germinating acorns developed a healthy top. But gradually the rot crept up from the root and when the plumule was affected, the acorns became unsuitable for planting. After 32 weeks of stratification only 36 per cent of the acorns developed a shoot.

Treatment of stored cork-oak acorns with naphthaleneacetic acid.

Guthrie (3) has shown that naphthaleneacetic acid has an inhibiting effect on the development of buds of potato tubers. It appeared desirable, therefore, to try this chemical as a germination-inhibitor of stored cork-oak acorns. On December 17, 1942, two 1-gallon jars were filled with freshly collected acorns. In one jar a small beaker was inserted containing 2.5 grams of crystalline alpha-naphthaleneacetic acid; the acorns in the other jar remained untreated and served as control. Both jars were tightly stoppered, and 100 acorns were withdrawn from the jars at certain intervals. At the time of writing this report (September 1943), control acorns still gave about 100 percent germination. The effect of naphthaleneacetic acid is shown in table 6 and figure 3.

Table 5.- Germination of California cork-oak acorns stored under different conditions.

	Germination percentage after different periods of storage													
	Weeks													
Storage conditions	0	2	4	6	8	10	12	16	20	24	28	32	34	Remarks
<u>Warm-room storage</u>														
Paper bags	96	15	5		0									
Sand, open container	93	58	22		12		4	0						
<u>Cold storage</u>														
Paper bags	100	88	21		0									
Mixed with dry sand in airtight 5-gal. cans	100	100	100		98		96	98	96	100		86		In progress
Bulk, in airtight 5-gal. cans	85		84		86		84		83		84			In progress
Stratified in moist peat in 10-gal. cans	100				100		98 ^{1/}		93 ^{1/}	60	36			In progress
Burlap sack ^{2/}	100		100				96							

^{1/} Germinated in storage. Tips of roots dead. Development of additional roots and of the shoots is satisfactory.

^{2/} The acorns used in this test were withdrawn from a large shipment brought from Chico early in January and stored in a commercial cold-storage house in burlap sacks.



Figure 3.- Effect of naphthaleneacetic acid on germination of cork-oak acorns. Untreated acorns developed normally; those kept in presence of the acid for 132 days failed to develop shoots.

Table 6.- Germination and development of stored cork-oak
acorns treated with naphthaleneacetic acid.

Date stored	Length of: storage	Days germinated						Development
		1	3	7	21	28	63	
	Days	Percent						
Dec. 17	0	0	90	100				All developed shoots.
Feb. 1	45	0	88	100				All developed shoots.
Mar. 1	73	0	94	100				All developed shoots.
Mar. 29	102	0	0	3	56	84		Only 14% developed shoots.
Apr. 28	132	0	0	0	0	1	36	No shoot development.
May 24	158	0	0	0	0	0	8	No shoot development.
June 19	184	0	0	0	0	0		No shoot development.

It is seen from table 6 that 73 days of storage in the presence of naphthaleneacetic acid has no effect on germination and immediate development of the acorns. The shoots developed normally. Acorns kept in the presence of the chemical for more than 73 days differed markedly from the control acorns. One week after planting, 82 percent of the control acorns developed normal roots averaging 35 mm. in length, but only 14 percent of the treated acorns developed roots, these averaging 21 mm. in length. The longer the acorns were kept under the influence of naphthaleneacetic acid the more evident became the inhibiting effect of the chemical on the development of the acorns. Apparently it was killing the meristems of both shoot and root; when the root meristem was killed additional roots were formed above the root's tip. These roots had the appearance of distorted appendages. In many cases when plumule, hypocotyl, and root were killed, filiform roots developed on the petioles of the cotyledons. This interesting phenomenon will be discussed later.

Treatment of acorns with naphthaleneacetic acid has a peculiar effect. First, it arrests development of the shoots; after more prolonged treatment it kills both root and shoot apical meristems but it does not kill cotyledons. When untreated acorns are placed in germination flats they either germinate or rot, depending on their viability, but when acorns are kept in cold storage in the presence of naphthaleneacetic acid say, for 150 or 180 days, and are subjected to germination tests, they neither germinate nor rot.^{3/} They rupture the fruit coat, increase in size, and acquire a dark green color. Many of them eventually develop fibrous roots. Some of these rooted acorns have been under observation for 8 months and they look as healthy as at the beginning of the experiment. Since the cotyledons have acquired a green color — i.e. developed chlorophyll — they can photosynthesize and will probably live for a long time. However, they cannot develop bud-producing initials. In this respect they resemble leaves of certain plants, such as Ficus elastica, which can develop roots but not shoots.

^{3/} A similar phenomenon occurs when the plumule and the hypocotyl are injured by fungi.

The capacity of developing roots on cotyledons has apparently never been observed on plants other than cork oak. This phenomenon was described by Pravdin (8) and has been verified during the present experiments. (Pravdin's work was not known to the author at the time the experiments were performed.) Although of no immediate practical importance, this unusual phenomenon is of considerable scientific interest and value.

Since cork-oak acorns have a peculiar capacity to develop roots without developing shoots, it appears advisable at least in practical work to judge viability of the acorns only by their capacity to develop shoots.

The experiment indicates that moderate treatment with naphthalene-acetic acid may be used to prevent immediate germination of newly harvested cork-oak acorns. More experiments of this kind are planned for the 1943 harvesting season.

Treatment of stored cork-oak acorns with some other substances

Naphthaleneacetic acid is not the only chemical material that retards the growth of plants. It has been found by Denny (1) and Guthrie (3) that derivatives of this acid, such as its methyl ester, are even more efficient in arresting growth than the acid itself. Marth (7) used also naphthaleneacetonitrile for checking the bud development of stored rose bushes. Sell et al. (9) prolonged dormancy of tung tree buds by treating them with naphthaleneacetic amide. It appears that many other substances that interfere with the orderly metabolism of plants affect their growth. Gray and Fuller (2) investigated a possible effect of mercury vapors on germination of various vegetable seeds; they reported that the seeds kept in the presence of mercury for 6 months suffered no ill effect. It has also been shown that growth-regulating substances are found in tar and in petroleum oil. It appeared of interest to investigate the effect of these substances on cork-oak acorns. Methyl ester and acetonitrile of naphthalene-acetic acid were not obtainable, but a test was made with the other substances mentioned — mercury, asphaltum varnish, and acetamide of naphthalene-acetic acid.

Four 1-quart jars were filled on March 12 with acorns of high viability (previously stored in dry sand in an airtight can). To the first jar was added 10 cc. of mercury, to the second jar an equal amount of asphaltum varnish, to the third jar 2.5 grams of acetamide of naphthalene-acetic acid. The acorns in the fourth jar were not treated and served as a check. After 2 months acorns were withdrawn from each jar and germinated. The results of this test are presented in table 7 and figure 4.

Table 7.- Germination and development of cork-oak acorns
stored for 2 months under different treatments.

Treatment	Germination		Number of seedlings with tops	Average ^{1/} height of seedlings	Remarks
	10	18			
	days	days			
	Percent	Percent			
Not treated	96	98	43	5.9 cm.	
Mercury	100	100	46	7.8 cm.	
Asphaltum varnish	98	98	40	3.4 cm.	
Acetamide	82	94	28	2.4 cm.	

^{1/} Measurement of the tops was made on June 17. A statistical analysis showed the difference in height growth to be highly significant.

From the germination behavior of the acorns withdrawn 2 months after the beginning of the experiment, it appears that acetamide definitely retarded development of the roots and the shoots. Asphaltum varnish retarded development of the shoots, although the roots developed normally. The effect of mercury was unexpected: the acorns treated with this substance germinated the best and showed the most vigorous root development and the best shoot growth when measured 1 month after planting the acorns. The results of this experiment warrant a further investigation of the effect of acetamide of naphthaleneacetic acid as a growth-arresting agent for stored acorns.

PREPARATION OF CORK-OAK ACORNS FOR SHIPPING

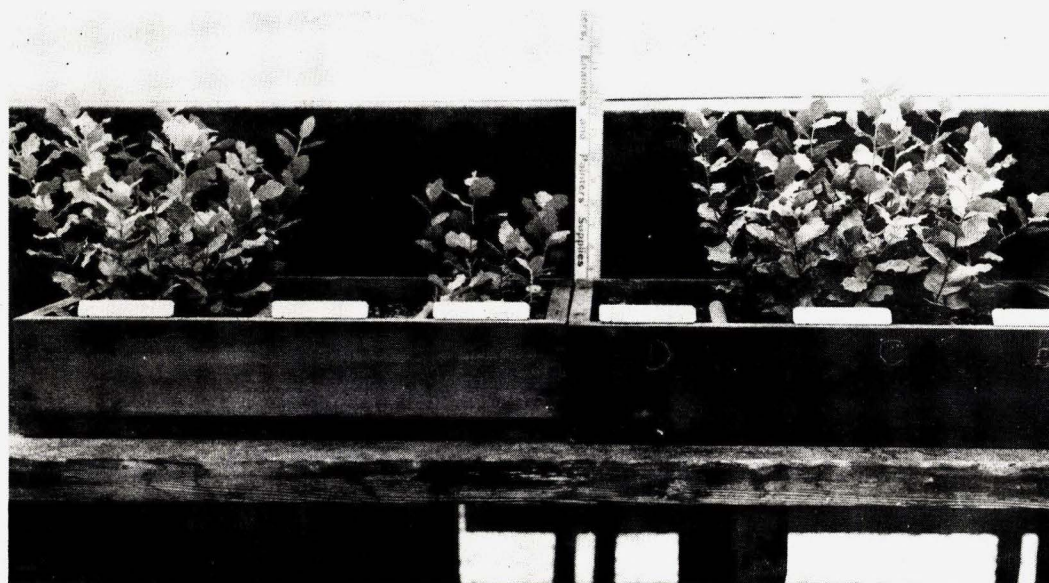
Maintaining viability of cork-oak acorns during transport from the place of harvest to the locality of planting is essentially a problem of storage. Experience with storage of cork-oak acorns suggests that if freshly collected acorns are packed in burlap sacks holding about 100 pounds, they can be shipped by truck to any point in the State where cork oak is to be planted. Low temperatures prevailing during the ripening season of the acorns and a distance measured by only a few days of travel assure perfect preservation of the viability of the acorns. If the shipment of acorns is delayed and made by freight train for a long distance, the problem becomes more difficult.

Experiments to determine the maintenance of viability in transit consisted in storing the acorns in a warm room under different conditions. In one experiment freshly collected acorns were dipped in either melted paraffin or liquid wax and kept on the laboratory bench for 19 days.^{4/}

^{4/} Pravdin (8) reported that he put lots of 50 cork-oak acorns in small metal containers and poured melted paraffin into the containers. After 30 days of room storage, the acorns gave 100 percent germination.



1 2 3 4
Figure 4.- Development of cork-oak seedlings after treatment of the acorns for 2 months with different substances. Acorns were (1) treated with acetamide of naphthaleneacetic acid, (2) treated with asphaltum paint; (3) untreated; (4) kept in presence of mercury.



1 2 3 4 5 6
Figure 5.- Seedlings grown from cork-oak acorns treated and untreated with commercial wax emulsion. Treatments and containers (described in table 8) were (1) untreated, jars; (2) wax and naphthalenaecetic acid, bags; (3) wax and naphthaleneacetic acid, jars; (4) wax, bags; (5) wax, jars; (6) untreated, bags. Note checking of growth of seedlings when naphthalenaecetic acid was added to wax emulsion.

Germination of the paraffin-dipped acorns amounted to 54 percent in 7 days; those dipped in liquid wax did not germinate; untreated freshly collected acorns gave 94 percent germination.

In another experiment the acorns were kept for 2 weeks under conditions shown in table 8. The liquid wax used in these tests as a preserving agent was a commercial wax emulsion used previously by several workers to prevent the escape of moisture from plant material. In the present experiments 1 part of the emulsion was mixed with 2 parts of water; the acorns were dipped in the emulsion and allowed to dry for 30 minutes before they were put in containers.

Table 8.- Storage of cork-oak acorns under conditions to be used in shipment.

Treatment and container for 2-week period		: Germination : in 7 days ^{1/}
		<u>Percent</u>
Untreated		
Paper bags		0
Airtight quart-size glass jars		96
Dipped in 1:2 solution of commercial wax emulsion		
Paper bags		0
Airtight quart-size glass jars		90
Dipped in 1:2 solution of commercial wax emulsion to which 0.5 grams of naphthaleneacetic acid had been added.		
Paper bags		0
Airtight quart-size glass jars		94

^{1/} Control acorns, taken directly from cold storage and planted, gave 96 percent germination.

Dipping in a solution of commercial wax emulsion did not prevent the loss of moisture from the acorns. Packing acorns in airtight jars preserved their original viability. A slight odor of fermentation in the jars, resembling the odor of apples, was probably due to spoiling of one or two acorns. It is evident from table 8 that treatment of jar-stored acorns with wax emulsion is not necessary. Addition of naphthaleneacetic acid to wax emulsion caused the usual retarding effect on development of the acorns. The results of this experiment are shown in figure 5. The photograph was taken 3 months after planting.

In view of our present experience, however meager, the shipping of acorns in bulk should be avoided. The best method of shipping cork-oak acorns is to pack them in 100-pound burlap sacks and keep them under refrigeration (from 32° to 40° F.) while in transit. Small samples of acorns packed in airtight quart-size containers can withstand at least a 2-week period in transit.

SUMMARY AND CONCLUSION

This report covers the first year of experimental work with germination and storage of cork oak acorns. Cork oak acorns are very similar to acorns of all other species of the white oak group, but they do not exhibit the dormancy phenomenon and they germinate as soon as they fall from the trees in the autumn. The acorns gathered in the fall of 1942 in different localities of California usually varied in weight from 90 to 150 acorns to the pound, although occasionally the acorns were much larger or much smaller. The moisture content of California cork oak acorns is about 75 to 80 percent of their dry weight; when their moisture is decreased to 30 or 35 percent the acorns lose their capacity to germinate. In order to assure high viability of stored cork oak acorns, their moisture content should be maintained at a high level.

Germination of cork oak acorns has certain peculiarities. The initial stages of germination are accompanied by extensive growth of the hypocotyl, which reaches an underground length of 10 to 15 cm. Many buds are formed on the hypocotyl and these are capable of sprouting when the plumule is dead or when the main shoot has been removed. This capacity of developing hypocotyl buds has practical importance in assuring the survival of cork oak transplants when, for instance, the shoot is clipped off by rodents.

Storage of cork oak acorns at room temperature, either in bulk or in containers, is not recommended. Viability of the acorns can be maintained in cold storage (32° - 40° F.) for 10 weeks if they are packed in large burlap sacks or for 10 months, possibly longer, if they are mixed with dry sand in airtight 5-gallon cans. Stratification in moist peat is not advisable.

The effect of growth-inhibiting substances on germination and development of cork oak acorns was studied. The experiments seem to indicate that treatment with naphthaleneacetic acid and its derivatives for a short period of time might retard the germination of cork oak acorns. Further experiments are needed in this direction.

Harvested cork oak acorns in 100-pound burlap sacks can be shipped by truck to place of planting in California. Shipping in burlap sacks by express or freight is not recommended. Small lots can be sent in airtight containers by mail or express. When shipped in 1 quart jars the acorns retain their original viability for at least 2 weeks.

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